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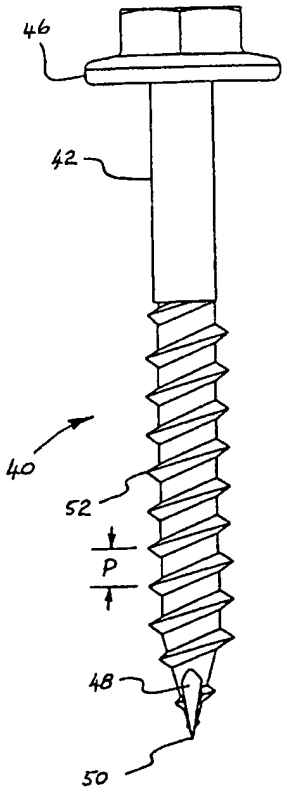
(54) Title: IMPROVEMENTS RELATING TO SELF-DRILLING SCREWS



(57) **Abstract:** A self-drilling screw fastener (40) has a shank (42) with a drive head at one end and a penetrating portion at the other end, the portion ending at a sharp tip (50). A single-start screw thread (52) runs from the tip (50) towards the head. The thread (52) comprises a helical ridge rising from a core portion of the shank (42). At the penetrating portion of the screw fastener (40), there is an elongate indentation (48) having a total length in the range of 1.0 to 3.0 times the pitch (P) of the thread (52), a maximum width in the range of 18 % to 55 % of the diameter of the shank (42), and one end substantially at the tip (50). The preferred method of manufacture is to roll form the thread (52) and the indentation (48) in a single pass of a roll-forming die.

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Published:
— *With international search report.*

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IMPROVEMENTS RELATING TO SELF-DRILLING SCREWS

Background and Summary of the Invention

This invention concerns self-drilling screw fasteners and their manufacture. Self-drilling screws are well known to those skilled in the art. They do not require a pre-drilled hole for installation.

A particular type of self-drilling screw is designated the Type 17 screw in Australian Standard 3566-1988 and this is widely known as the T-17 screw. It is typically used for fastening to timber and also has the capability of readily drilling through sheet steel up to about 0.42mm thick. T-17 screws are therefore particularly useful for fastening sheet metal such as roof cladding or other building components to timber battens. A version of T-17 screw has a hexagonal head having an integrated flange collar and is ideal for powered screwdriver applications. Other head types such as Bugle Head and Wafer Head are also used with T-17 screws. The ability to be installed by a powered screwdriver is one of the significant features of T-17 screw.

In order to promote drilling through thin steel sheet and timber, during manufacture a slot is machined into the point of a T-17 screw after the thread is rolled onto the screw. This slot provides a cutting edge at the point of the fastener. While T-17 screws have achieved significant success in the marketplace, they suffer from a disadvantage that it often takes some seconds of rotating the screw in contact with steel sheet before the point penetrates through the sheet. This is because of a combination of the tip being insufficiently sharp, the screw tip being insufficiently hard, and the slot not engaging with the steel sufficiently quickly. Furthermore, as the slot is created in a secondary manufacturing operation, after the thread is formed on the screw, it adds significant costs and time to the manufacturing of the product.

Substantial testing has now revealed that for T-17 screws, only the portion of the machined slot closest to the very tip of the fastener makes any significant contribution to the efficiency of the drilling operation. The large size of the slot on presently

available T-17 fasteners is due to the production technique conventionally used wherein a circular slotting saw, or other cutting or grinding device, is engaged with the screw tip to cut the slot. The shape of the slot on presently available T-17 fasteners is governed by this manufacturing technique.

The cutting of the notch requires the expense and time of a separate machining operation after the thread is rolled on the screw. Also the machining of such a slot has three significant detrimental effects.

1. The removal of a significant amount of material from the tip reduces the structural strength of the tip so making it susceptible to blunting.
2. The cutting of metallurgical grains at the face of the tip, weakens those grains making them susceptible to structural failure when loaded, thus leading to rapid blunting of the point when used.
3. The slot has a tendency to entrain wood cuttings and fibres within the first few rotations of the screw and the presence of this material increases the friction force so increasing the torque required for installing the screw.

An aim of the present invention is to provide a self-drilling screw and a method of manufacturing a screw which overcome one or more of these difficulties. In the preferred embodiments, all of these difficulties are avoided or at least substantially reduced.

Accordingly, in a first aspect the invention provides a self-drilling screw fastener comprising:

a shank having a drive head at one end, a penetrating point at the other end, said point ending at a sharp tip, and a single-start screw thread running from said tip toward said head;

said thread comprising a helical ridge rising from a core portion of the shank;

said point having an elongate indentation formed longitudinally into the core portion; and

said indentation having a total length in the range of 1.0 to 3.0 times the pitch of the screw thread, a maximum width in the range of 18% to 55% of the diameter of the shank, and having one end substantially at the tip.

In a second aspect the invention provides a method of forming a self-drilling screw fastener comprising:

roll forming a thread on a shank portion of the screw; and

roll forming an elongate indentation into the point of the screw such that the indentation has:

one end substantially at the tip,

a total length in the range of 1.0 to 3.0 times the pitch of the screw thread, and

a maximum width in the range of 18% to 55% of the diameter of the shank.

Preferably the indentation is aligned on that side of the point where the thread reaches the tip. Preferably the indentation has a total length in the range of 1.0 to 2.5 times the pitch of the screw thread, more preferably in the range of 1.5 to 2.0 times the pitch. Preferably the indentation has a maximum width in the range of 25% to 45% of the diameter of the shank. Preferably the thread and the indentation are formed in a single pass of a roll-forming die.

The indentation preferably presses through the ridge of the thread at a distance from the tip of the fastener which is within 25% of the pitch of the thread and more preferably at a distance from the tip which is between 2% and 20% of the pitch of the thread. The indentation more preferably presses through the ridge of the thread at a distance from the tip which is between 4% and 10%, more preferably between 5% and 8%, of the pitch of the thread.

The indentation preferably has the shape of an elongated teardrop and is oriented so that the rounded end of the indentation is directed away from the tip of the fastener, ie. the pointed end of the teardrop is at the extreme tip of the point of the fastener. The indentation preferably has a generally shallow concave shape.

Brief Description of the Drawings

In order that the invention may be more fully understood there will now be described, by way of example only, preferred embodiments and other elements of the invention with reference to the accompanying drawings where:

Figures 1 and 2 are orthogonal side views of a conventional T-17 screw;

Figure 3 is an end view looking at the pointed tip of the screw shown in Figures 1 and 2,

Figures 4 and 5 are orthogonal side views of a screw according to the present invention;

Figure 6 is an end view looking at the pointed tip of the screw shown in Figures 4 and 5,

Figure 7 is an enlarged detail of the point of the screw in Figure 4;

Figure 8 is a cross section through the point of the screw along plane A-A shown in Figure 7;

Figure 9 is a cross section view through the point of the screw along plane C-C shown in Figure 7;

Figure 10 is a side view of a die used in roll forming the screw shown in Figures 4 to 6;

Figure 11 is a plan view of the die shown in Figure 10 when viewed in the direction of arrow B indicated in Figure 10;

Figure 12 is an isometric view of an insert for use with the die shown in Figures 10 and 11; and

Figures 13, 14 and 15 are orthogonal views of the insert shown in Figure 11.

Detailed Description of the Invention

Referring to Figures 1 to 3, the conventional T-17 self-drilling screw fastener 10 has a shank 12 with a hexagonal drive head 13 at one end and a tapered penetrating point 14 at the other end. The screw 10 has a flanged collar 16 integrally formed with the shank 12 and head 13. A slot 18 extending from the tip 20 of the point 14 cuts

through the threads and into the core 24 of the screw at the tip 20. The slot 18 is formed by engaging the screw tip 20 with a cutting wheel or saw after the thread 22 is formed on the screw. This removes material from the screw tip and leaves a slot 18 which has a flat face 28, which was formed against the flat side face of the cutting disc or saw, and a curved face 30 which was formed by contact with the peripheral face of the cutter. The slot 18 extends for about four pitches of the thread 22, extending lengthwise into the shank 12 beyond the point 14 and into the cylindrical portion of the core 24.

Referring to Figures 4 to 9, the embodiment of the present invention shown therein is seen to have generally the same form as that of the T-17 screw shown in Figure 1. The screw 40 has a shank 42 with a hexagonal drive head 43 at one end a pointed portion 44 at the other end. The point 44 ends at a sharp tip 50. A single start right-handed thread 52 has a helical ridge 53 rising from a core portion 54 of the screw and extends from the tip 50 for most of the way along the shank 42 towards the head 43 of the screw. The only significant difference between this screw 40 and the prior art screw 10 is the shape of the point where, instead of the cut slot 18, a smaller indentation 48 is formed into the point 44 so that it abuts the tip 50.

As best seen in Figures 6 and 7, the indentation 48, when compared with the slot 18, is much more symmetrical about a plane containing the longitudinal axis 56 of the screw and passing centrally through the indentation 48. The indentation 48 is elongated in the direction of the axis 56 of the screw and has a roughly teardrop shape with the indentation's sharper end pointing towards the tip 50 and the rounder end 49 pointing towards the head 43.

However the indentation 48 is not completely symmetrical. On one longer side of the indentation, the leading (cutting) edge 57 is longer and straighter than the trailing edge 58 on the opposite side. As best seen in Figure 9, that portion 59 of the face of the indentation 48 which is closest to the leading edge 57 is steeply inclined to the core surface 51 such that the face portion 59 creates a positive rake angle at the edge 57. In other words there is a form of undercut at the edge 57 so the edge 57 performs

as an excellent cutting edge when in use as it cuts through the steel sheet. In contrast, that portion 55 of the face of the indentation 48 which is closest to the trailing edge 58 approaches the core surface 51 less acutely and creates a negative rake angle at the edge 58.

The above description relates to a screw 40 having a right-handed thread and the relative characteristics of the edges 57 and 58 would need to be reversed for a screw with a left-handed thread.

In the embodiment shown, the indentation 48 passes through two ridges 53 of the thread, it has a total length (shown in dimension L in Figure 8) of about 1.8 times the thread pitch length (shown as dimension P in Figure 6) and a maximum width (shown as dimension W in Figure 7) of about 30% of the shank diameter (shown as dimension D in Figure 5), and the thread stops slightly short of the tip 50 of the point.

However in a more preferred embodiment, the indentation 48 intersects the ridge 53 of the thread closer to the tip 50. In fact the positioning of the indentation causes the thread to fall short of the tip 50 by about 5 to 8% of the pitch. The indentation is aligned on the point such that the thread almost, but not quite, reaches the tip. It has also been found that substantially reduced installation times can be achieved by this careful positioning of the slot circumferentially around the screw relative to the thread ridge at the very tip of the screw.

It has been found from experiments that a notch longer than that shown in Figure 7 does not significantly improve the self-drilling ability of the screw in practice. In addition the smaller sized notch has a substantial advantage when manufactured in accordance with the preferred method as will now be described.

The indentation 48 is formed by plastic deformation of the steel at the screw point rather than by removal of the steel as in the prior art T-17. The plastic deformation causes work-hardening and hence produces a harder point compared to that of the

machined slot. Because the metallurgical grains at the tip have not been cut, this leads to the tip maintaining its sharpness longer than the prior art.

The material plastically deformed from the indentation 48 is displaced towards the tip 50, so allowing the creation of a more gently tapered (ie sharper) tip. The taper on the screw point overall is the same as that of the prior art T-17 screw but the tip is less rounded. The material plastically deformed towards the tip allows the tip to be elongated from its conventional configuration to produce an almost needle-sharp extremity. The present invention provides a screw having a reduced installation torque and improved speed of installation.

Referring to Figures 10 and 11, these show a generally conventional thread rolling die 60 well known to those skilled in the art. The significant difference between this die 60 and dies previously used for the manufacture of T-17 screws is the provision of a cavity 62, within which a die insert 72 is fixed, towards the right-hand side of the die.

The insert 72, which for clarity is not shown in Figures 10 and 11 but is shown separately in Figures 12 to 15, carries a raised protrusion 74 of size and shape required to produce an indentation 48 of the required size and shape as described above. The exact size and position of the insert 72 and the configuration of the protrusion 74 thereon may be readily determined by a thread rolling die maker skilled in the art. However Figures 12 to 15 show the required shape and the necessary absolute dimensions are determined by the screw size. The insert 72 is held rigidly within the cavity 62 during the thread rolling operation as is fitted with its end face 78 aligned with the side face 68 of the die 60. The prismatically shaped protrusion 74 is configured to press into the screw tip and produce a notch of the required form.

The thread rolling process commences with the unthreaded shank of the screw brought into contact with the left-hand side 66 of the die as viewed in Figures 10 and 11 and is then pressed against the working face 76 of the die while being rolled between such dies at high pressure, the screw rolling from left to right over the die.

The die 60 is sized such that the screw performs about 7 or 8 rotations between the dies while the thread is rolled onto the screw.

The die insert in the cavity 62 is positioned and sized such that after the indentation 48 is initially impressed into the point, further rolling of the thread occurs to smooth out the displaced material, without destroying the major features of the indentation, before the screw is released from between the dies.

An advantage of the present invention over prior art T-17 screws with their machined slots is that the indentation of the present invention does not have all the broken grain boundaries produced by the machining of the prior art slots, so offering greater wear resistance.

Whilst the above description includes the preferred embodiment of the invention, it is to be understood that many variations, alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the essential features or the spirit or ambit of the invention.

It will be also understood that where the word "comprise", and variations such as "comprises" and "comprising", are used in this specification, unless the context requires otherwise such use is intended to imply the inclusion of a stated feature or features but is not to be taken as excluding the presence of other feature or features.

Claims

1. A self-drilling screw fastener comprising:

a shank having a drive head at one end and a penetrating point at the other end, said point ending at a sharp tip, and a single-start screw thread running from said tip toward said head;

said thread comprising a helical ridge rising from a core portion of the shank;

said point having an elongate indentation pressed through the thread and into the core portion; and

said indentation having a total length in the range of 1.0 to 3.0 times the pitch of the thread, a maximum width in the range of 18% to 55% of the diameter of the shank, and having one end substantially at the tip.

2. A fastener according to claim 1 wherein the indentation has a total length in the range of 1.0 to 2.5 times the pitch of the thread.

3. A fastener according to claim 2 wherein the indentation has a total length in the range of 1.5 to 2.0 times the pitch of the thread.

4. A fastener according to any one of the previous claims wherein the indentation has a maximum width in the range of 25% to 45% of the diameter of the shank.

5. A fastener according to any one of the previous claims wherein the indentation is aligned on that side of the point where the thread reaches the tip.

6. A fastener according to any one of the previous claims wherein the indentation presses through the ridge of the thread at a distance from tip which is within 25% of the pitch of the thread.

7. A fastener according to claim 6 wherein the indentation presses through the ridge of the thread at a distance from tip which is between 2% and 20% of the pitch of the thread.

8. A fastener according to claim 7 wherein the indentation presses through the ridge of the thread at a distance from tip which is between 4% and 10% of the pitch of the thread.

9. A fastener according to any one of the previous claims wherein the indentation has a generally elongated teardrop shape having its rounded end directed away from the tip of the fastener.

10. A fastener according to any one of the previous claims wherein the indentation has a shallow concave shape.

11. A method of forming a self-drilling screw fastener comprising:

roll forming a thread on a shank portion of the screw; and

roll forming an elongate indentation into the point of the screw such that the indentation has:

one end substantially at the tip,

a total length in the range of 1.0 to 3.0 times the pitch of the screw thread, and

a maximum width in the range of 18% to 55% of the diameter of the shank.

12. A method according to claim 11 wherein the thread and the indentation are formed in a single pass of a roll forming die.

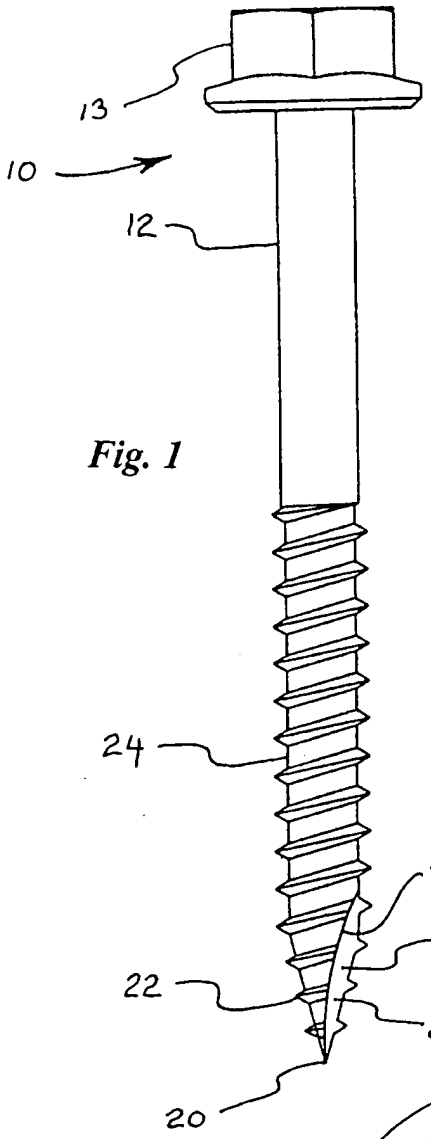

Fig. 1

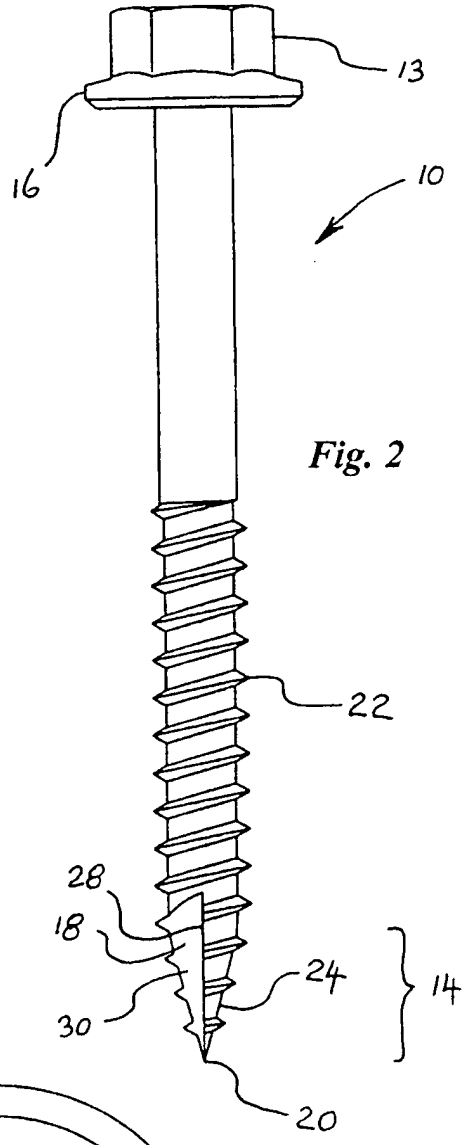

Fig. 2

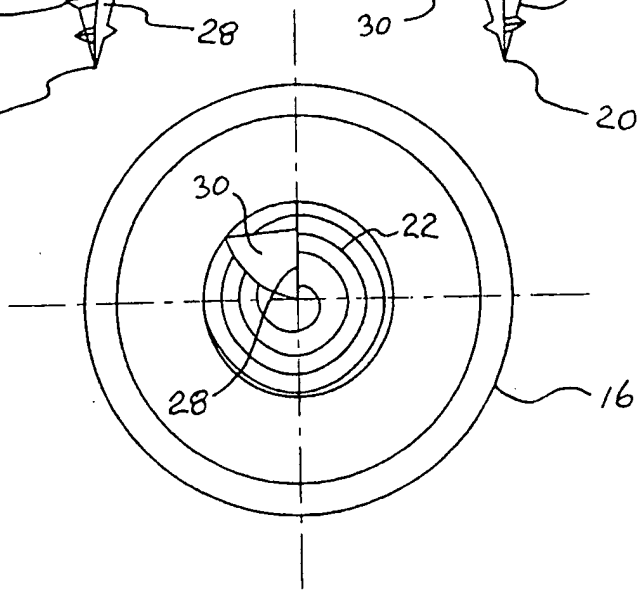

Fig. 3

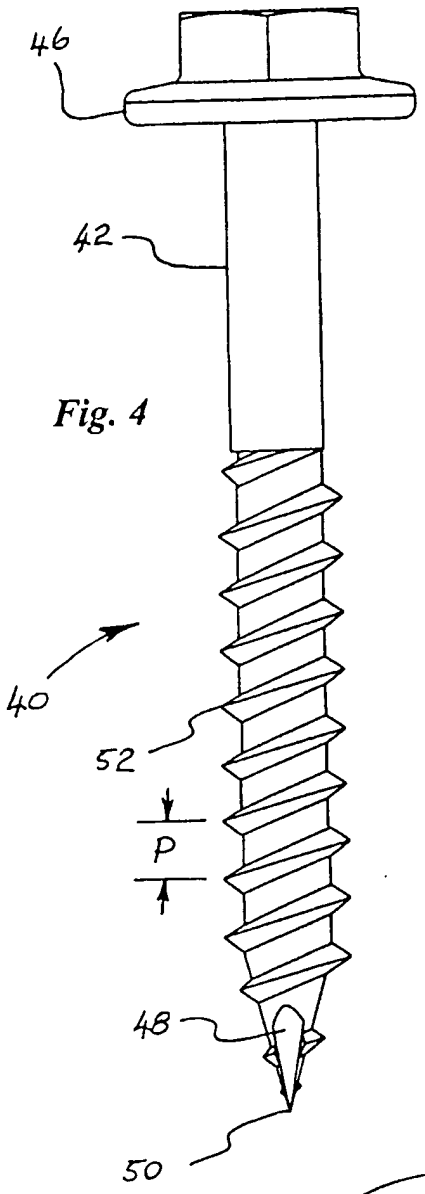

Fig. 4

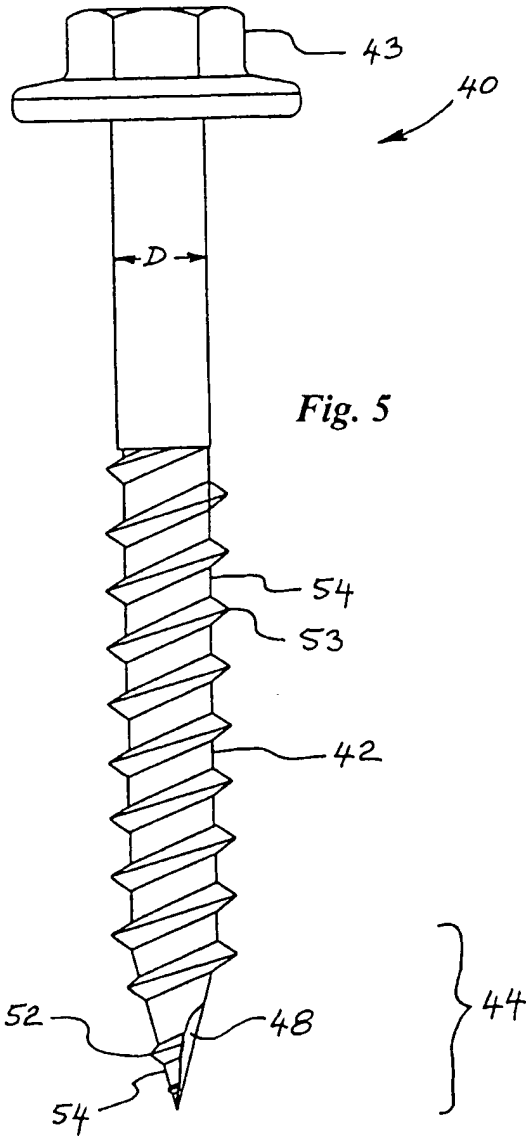

Fig. 5

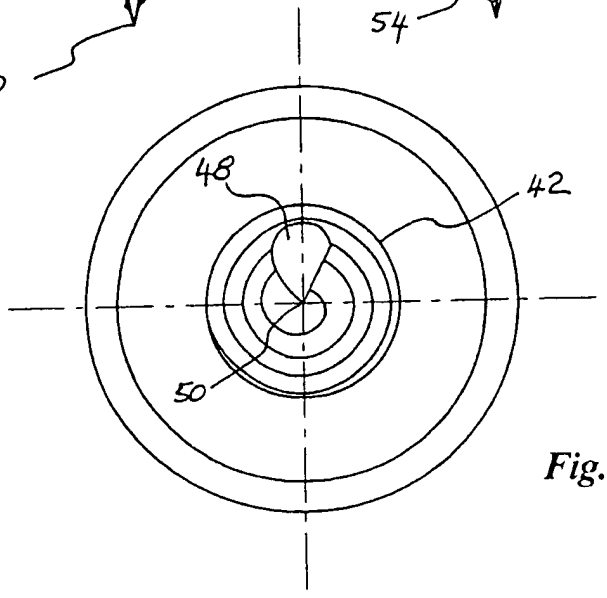

Fig. 6

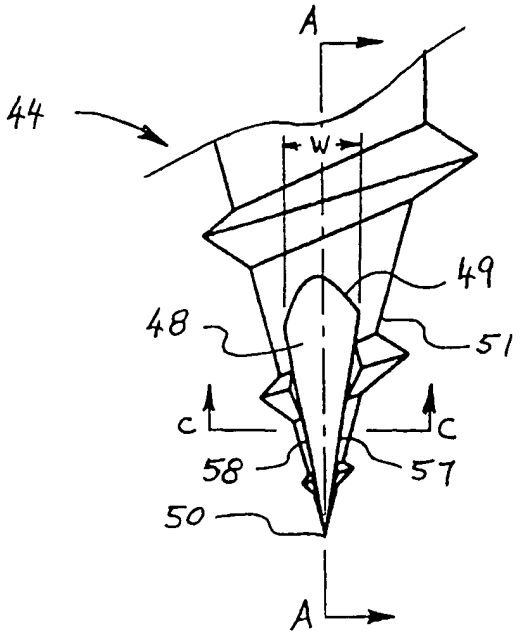

Fig. 7

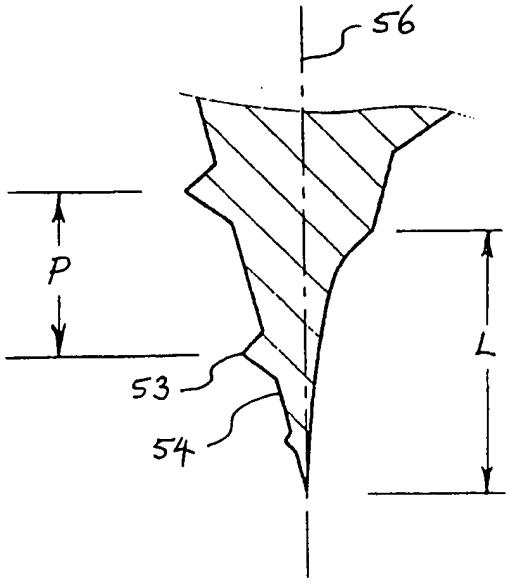

Fig. 8

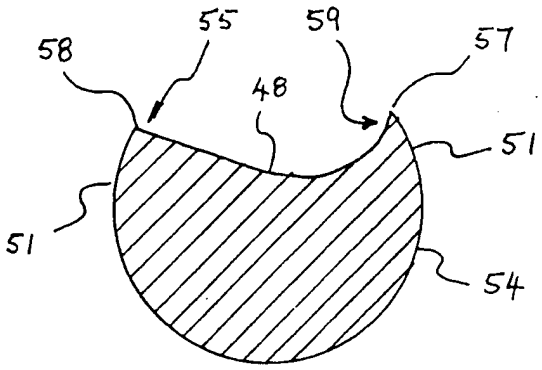

Fig. 9

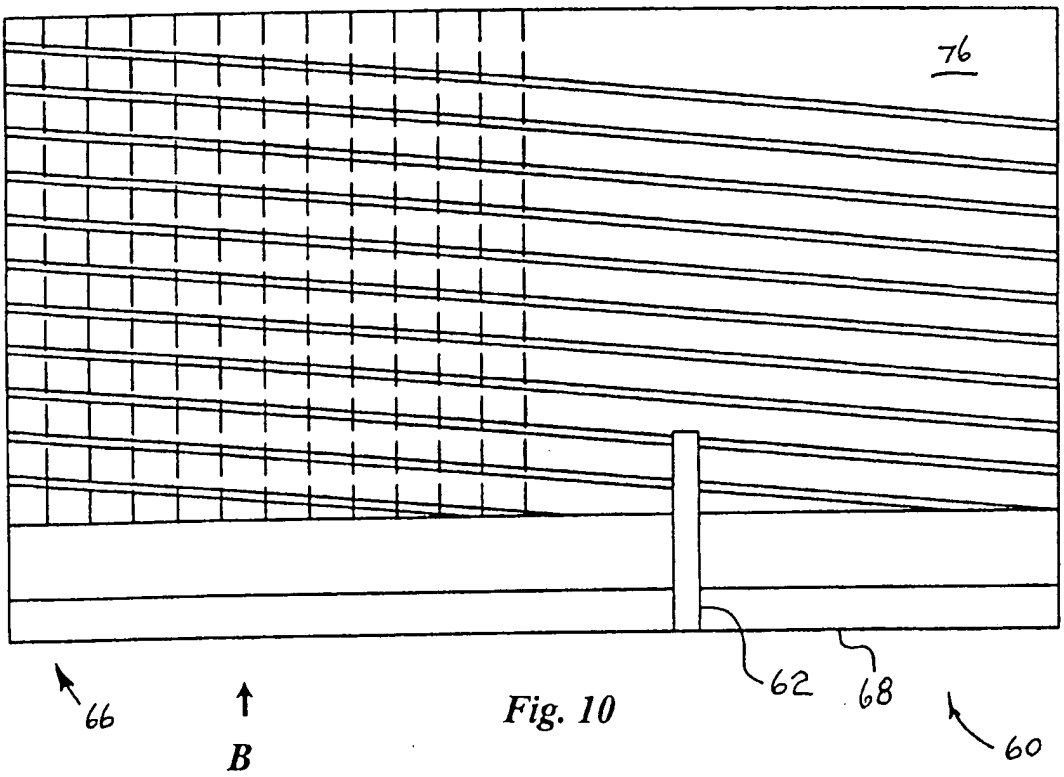

Fig. 10

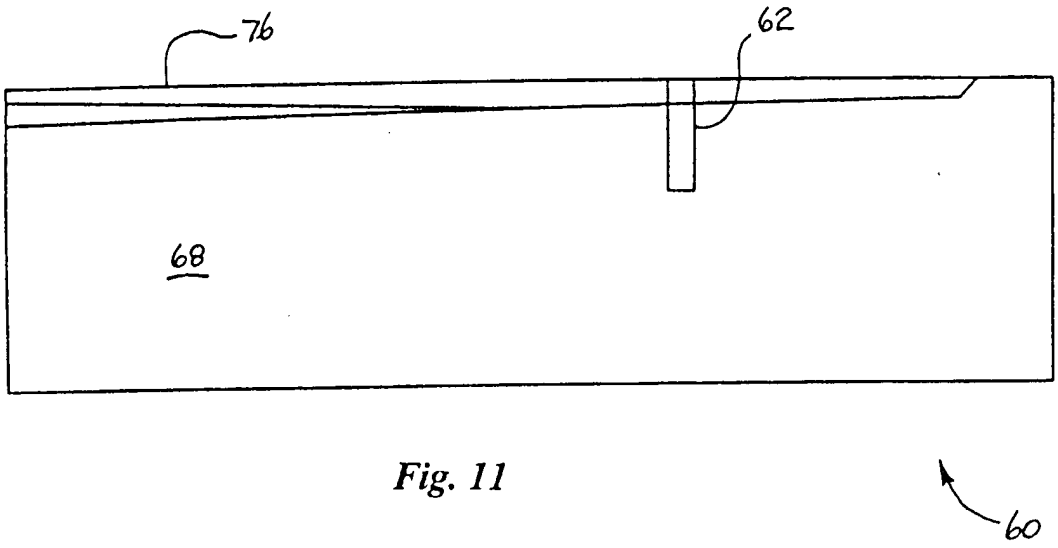

Fig. 11

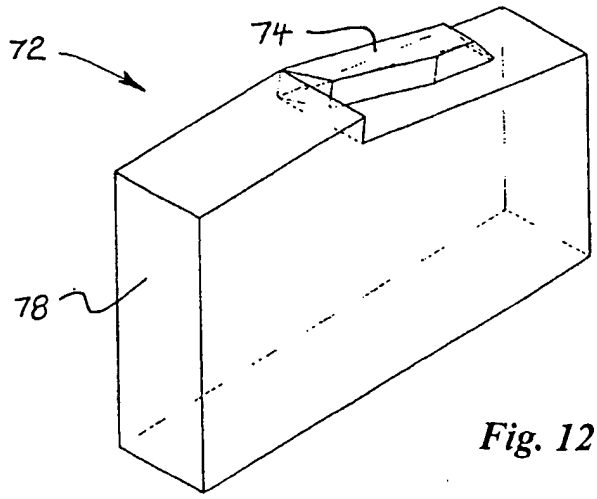

Fig. 12

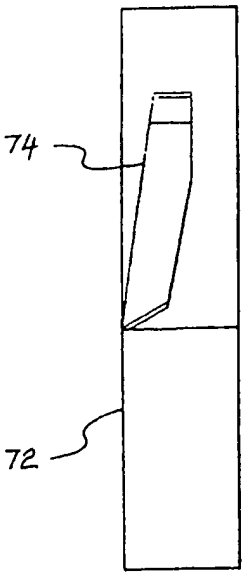

Fig. 13

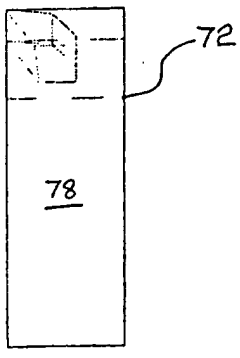

Fig. 14

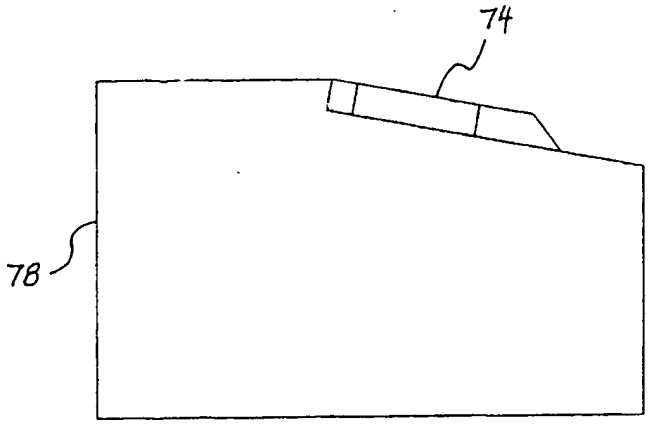

Fig. 15

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 00/01057

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[7]: F16B 25/10, E04D 3/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC F16B 25/10, E04D 3/36

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Derwent Abstract Accession No. 98-350722/31, Class Q61, JP 10-131932 A (NITTO SEIKO KK) 22 May 1998 whole abstract	1-12
A	EP 918165 A (W.A. DEUTSHER PTY.LTD) 29 May. 1999 whole document	1-12
P,A	US 5947670 A (LARSON) 7 September 1999 whole document	1-12

☐ Further documents are listed in the continuation of Box C

☒ See patent family annex

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Date of the actual completion of the international search
28 September 2000

Date of mailing of the international search report
09 OCT 2000

Name and mailing address of the ISA/AU

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 00/01057

Information on patent family members

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member	
EP	918165	AU	93224/98
US	5947670	NONE	

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